



MarLIN

Marine Information Network

Information on the species and habitats around the coasts and sea of the British Isles

Venerupis corrugata, *Amphipholis squamata* and *Apseudes holthuisi* in infralittoral mixed sediment

MarLIN – Marine Life Information Network
Marine Evidence-based Sensitivity Assessment (MarESA) Review

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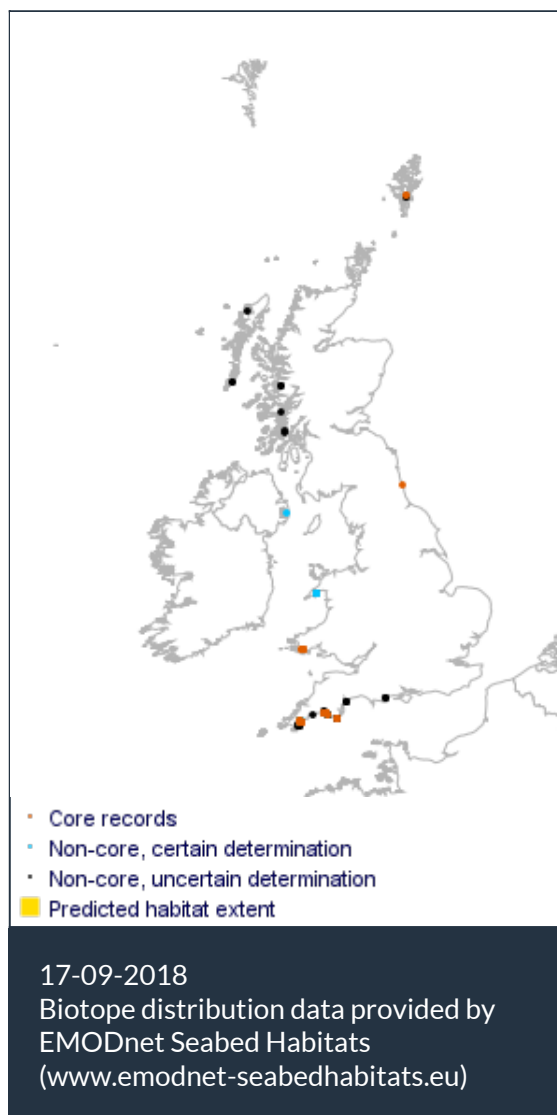
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Researched by Dr Heidi Tillin & Will Rayment

Refereed by This information is not refereed.

Summary

☰ UK and Ireland classification

EUNIS 2008 A5.433

Venerupis senegalensis, *Amphipholis squamata* and *Apseudes latreilli* in infralittoral mixed sediment

JNCC 2015 SS.SMx.IMx.VcorAsquAps

Venerupis corrugata, *Amphipholis squamata* and *Apseudes holthuisi* in infralittoral mixed sediment

JNCC 2004 SS.SMx.IMx.VsenAsquAps

Venerupis senegalensis, *Amphipholis squamata* and *Apseudes latreilli* in infralittoral mixed sediment

1997 Biotope SS.IMX.FaMx.VsenMtru

Venerupis senegalensis and *Mya truncata* in lower shore or infralittoral muddy gravel

🔍 Description

Sheltered muddy sandy gravel and pebbles in marine inlets, estuaries or embayments with variable salinity or fully marine conditions, support large populations of the pullet carpet shell *Venerupis*

senegalensis with the brittlestar *Amphipholis squamata* and the tanaid *Apseudes latreilli*. This biotope may be found at a range of depths from 5m to 30m although populations of *Venerupis senegalensis* may also be found on the low shore. Other common species within this biotope include the gastropod *Calyptraea chinensis*, a range of amphipod crustacea such as *Corophium sextonae* and *Maera grossimana* and polychaetes such as *Mediomastus fragilis*, *Melinna palmata*, *Aphelochaeta marioni*, Syllids and tubificid oligochaetes. Many of the available records for this biotope are from southern inlets and estuaries such as Plymouth Sound and Milford Haven but *Venerupis senegalensis* has a much wider distribution and it should be noted that northern versions of this biotope may have a much lower species diversity (JNCC, 2015).

↓ Depth range

0-5 m, 5-10 m, 10-20 m, 20-30 m

Additional information

-

✓ Listed By

- none -

Further information sources

Search on:



Habitat review

Ecology

Ecological and functional relationships

- The species composition of the biotope is probably determined largely by the substratum characteristics and therefore the hydrodynamic regime and sediment supply, rather than the interspecific relationships. Sediment is the most extensive sub-habitat within the biotope and hence infauna dominate.
- The suspension feeding infaunal bivalves, e.g. *Venerupis senegalensis*, *Abra alba*, *Kurtiella bidentata* and *Mya truncata*, compete for nutrients among themselves and with epifauna, e.g. *Mytilus edulis*.
- Spatial competition probably occurs between infaunal suspension feeders and deposit feeders. Reworking of sediment by deposit feeders, e.g. *Arenicola marina*, makes the substratum less stable, increases the suspended sediment and makes the environment less suitable for suspension feeders (Rhoads & Young, 1970). Tube building, e.g. by *Lanice conchilega*, and byssal attachment, e.g. by *Venerupis senegalensis*, stabilize the sediment and arrest the shift towards a community dominated by deposit feeders.
- Amphipods, e.g. *Corophium* sp., and the infaunal annelid species in this biotope probably interfere strongly with each other. Adult worms probably reduce amphipod numbers by disturbing their burrows, while high densities of amphipods can prevent establishment of worms by consuming larvae and juveniles (Olafsson & Persson, 1986). *Arenicola marina* has been shown to have a strong negative effect on *Corophium volutator* due to reworking of sediment causing the amphipod to emigrate (Flach, 1992).
- *Carcinus maenas* is a significant predator in the biotope. It has been shown to reduce the density of *Mya arenaria*, *Cerastoderma edule*, *Abra alba*, *Tubificoides benedii*, *Aphelochaeta marioni* and *Corophium volutator* (Reise, 1985). A population of *Carcinus maenas* from a Scottish sea-loch preyed predominantly on annelids (85% frequency of occurrence in captured crabs) and less so on molluscs (18%) and crustaceans (18%) (Feder & Pearson, 1988).
- Carnivorous annelids such as *Nephtys hombergii* and *Pholoe inornata* operate at the trophic level below *Carcinus maenas* (Reise, 1985). They predate the smaller annelids and crustaceans.
- *Cerastoderma edule* and *Mya arenaria* are common prey for several bird species. *Ensis* sp. and *Venerupis* sp. are also heavily predated (Meire, 1993). The main bird predator in the biotope is probably the oystercatcher, *Haematopus ostralegus*. Drianan (1957, cited in Meire, 1993) estimated that oystercatchers remove 22% of the cockle population annually in Morecambe Bay. It should be noted that only the upper portion of the biotope will be vulnerable to predation by shore birds at low tide.
- Macroalgae, e.g. *Fucus serratus*, colonize the hard substrata where present. The low energy environment allows colonization of gravel and pebbles which in higher energy environments would be too unstable.
- *Littorina littorea* and *Steromphala cineraria* graze microalgae and ephemeral green algae, preventing domination by the faster growing species. Calcareous species, e.g. the Corallinaceae, are resistant to grazing.

Seasonal and longer term change

Seasonal changes occur in the abundance of the fauna due to seasonal recruitment processes.

Venerupis senegalensis exhibits pronounced year class variability in abundance (Johannessen, 1973b; Perez Camacho, 1980) probably due to patchy recruitment and/or variable post recruitment processes. Variation in abundance is very pronounced in the polychaete *Aphelocheata marioni*. In the Wadden Sea, peak abundance occurred in January (71,200 individuals per m²) and minimum abundance occurred in July (22,500 individuals per m²) following maximum spawning activity between May and July (Farke, 1979). However, the spawning period varies according to environmental conditions and so peak abundances will not necessarily occur at the same time each year. Adult densities of the bivalve, *Abra alba*, may exceed 1000 per m² in favourable conditions but typically fluctuate widely from year to year due to variation in recruitment success or adult mortality (see review by Rees & Dare, 1993).

Macroalgal cover typically varies through the year due to temperature and light availability. *Fucus serratus* plants, for example, lose fronds in the winter, followed by regrowth from existing plants in late spring and summer, so that summer cover can be about 250% of the winter level (Hartnoll & Hawkins, 1980). Production by microphytobenthos and microalgae is also likely to be higher in spring and summer, increasing food availability for grazers, deposit feeders and suspension feeders.

One of the key factors affecting benthic habitats is disturbance, which in shallow subtidal habitats increases in winter due to weather conditions. Storms may cause dramatic changes in distribution of macro-infauna by washing out dominant species, opening the sediment to recolonization by adults and/or available spat/larvae (Eagle, 1975; Rees *et al.*, 1977; Hall, 1994) and by reducing success of recruitment by newly settled spat or larvae (see Hall 1994 for review). For example, during winter gales along the North Wales coast, large numbers of *Abra alba* were cast ashore and over winter survival rate was as low as 7% in the more exposed locations. The survival rates of the bivalve, *Kurtiella bidentata*, and the polychaete, *Notomastus latericeus*, were 50% and 12% respectively (Rees *et al.*, 1977). Sediment transport and the risk of smothering also occurs. A storm event at a silt/sand substratum site in Long Island Sound resulted in the deposition of a 1cm layer of shell fragments and quartz grains (McCall, 1977).

Habitat structure and complexity

- The mixed sediment in this biotope is the important structural component, providing the complexity required by the associated community. Epifauna and algae are attached to the gravel and pebbles and infauna burrow in the soft underlying sediment. Sediment deposition, and therefore the spatial extent of the biotope, is dictated by the physiography and underlying geology coupled with the hydrodynamic regime (Elliot *et al.*, 1998).
- There is a traditional view that the distribution of infaunal invertebrates is correlated solely with sediment grain size. In reality, and in this biotope, it is likely that a number of additional factors, including organic content, microbial content, food supply and trophic interactions, interact to determine the distribution of the infauna (Snelgrove & Butman, 1994).
- Reworking of sediments by deposit feeders, such as *Arenicola marina*, increases bioturbation and potentially causes a change in the substratum characteristics and the associated community (e.g. Rhoads & Young, 1970). The presence of tube builders, such as *Janice conchilega*, stabilizes the sediment and provides additional structural complexity.
- The presence of macroalgae, such as *Fucus serratus* and *Osmundea pinnatifida*, increases structural complexity in the biotope, providing shelter and cover for mobile fauna. The fronds increase the area available for attachment of epifauna and epiphytes.

Productivity

Primary production in this biotope comes predominantly from benthic microalgae (microphytobenthos e.g. diatoms, flagellates and euglenoides) and water column phytoplankton. Macroalgae, although not very abundant in the biotope also contribute to primary production. They exude considerable amounts of dissolved organic carbon which are taken up readily by bacteria and possibly by some larger invertebrates. Only about 10% of the primary production on rocky shores is directly cropped by herbivores (Raffaelli & Hawkins, 1999) and the figure is likely to be similar or less in this biotope. Photosynthetic processes may be light limited due to the turbidity of the water (Elliot *et al.*, 1998) and *in situ* primary production overall is likely to be low. Large allochthonous inputs of nutrients, sediment and organic matter come from river water and the sea, containing both naturally derived nutrients and anthropogenic nutrients (e.g. sewage) (Elliot *et al.*, 1998). The allochthonous nutrient input results in enriched sediments and explains the high biomass of detritivores and deposit feeders.

Recruitment processes

Characteristic and other species in the biotope recruit as larvae and spores from the plankton. More detailed information is given for dominant and characteristic species below.

- *Venerupis senegalensis* is a long lived, fast growing species that reaches maturity within one year and spawns several times in one season (Johannessen, 1973b; Perez Camacho, 1980). No information was found concerning number of gametes produced, but the number is likely to be high as with other bivalves exhibiting planktotrophic development (Olafsson *et al.*, 1994). The larvae remain in the plankton for up to 30 days (Fish & Fish, 1996) and hence have a high potential for dispersal. The species exhibits pronounced year class variability in abundance (Johannessen, 1973; Perez Camacho, 1980) which suggests that recruitment is patchy and/or post settlement processes are highly variable. Olafsson *et al.* (1994) reviewed the potential effects of pre and post recruitment processes. Recruitment may be limited by predation of the larval stage or inhibition of settlement due to intraspecific density dependent competition. Post settlement processes affecting survivability include predation by epibenthic consumers, physical disturbance of the substratum and density dependent starvation of recent recruits. Hence, for *Venerupis senegalensis*, annual predictable recruitment is unlikely to occur.
- Recruitment of shallow burrowing infaunal species can depend on adult movement by bedload sediment transport and not just spat settlement. Emerson & Grant (1991) investigated recruitment in *Mya arenaria* and found that bedload transport was positively correlated with clam transport. They concluded that clam transport at a high energy site accounted for large changes in clam density. Furthermore, clam transport was not restricted to storm events and the significance is not restricted to *Mya arenaria* recruitment. Many infauna, e.g. polychaetes, gastropods, nematodes and other bivalves, will be susceptible to movement of their substratum.
- The infaunal polychaetes *Arenicola marina* and *Aphelochaeta marioni* have high fecundity and the eggs develop lecithotrophically within the sediment or at the sediment surface (Farke, 1979; Beukema & de Vlas, 1979). There is no pelagic larval phase and the juveniles disperse by burrowing. Recruitment must occur from local populations or by longer distance dispersal during periods of bedload transport. Recruitment is therefore likely to be predictable if local populations exist but patchy and sporadic otherwise.
- The epifaunal gastropods in the biotope, such as *Littorina littorea*, are iteroparous, highly fecund and disperse via a lengthy pelagic larval phase. Recruitment is probably sporadic

and opportunistic, large spat fall occurring when a suitable substratum and food supply becomes available.

- Recruitment of *Fucus serratus* from minute pelagic sporelings takes place from late spring until October. There is a reproductive peak in the period August - October and dispersal may occur over long distances (up to 10 km). However, weak tidal streams may result in a smaller supply of pelagic sporelings and most recruitment probably comes from local populations.

Time for community to reach maturity

Venerupis senegalensis is the important characterizing species in the biotope. It is highly fecund and fast growing (Johannessen, 1973b; Perez Camacho, 1980; Olafsson *et al.*, 1994) and therefore is likely to attain high numbers in the community rapidly. The same is true for the majority of other infauna, epifauna and flora in the biotope. It is predicted therefore that the community will reach maturity in less than 5 years.

Additional information

no text entered.

Preferences & Distribution

Habitat preferences

Depth Range	0-5 m, 5-10 m, 10-20 m, 20-30 m
Water clarity preferences	Field Unresearched
Limiting Nutrients	Nitrogen (nitrates), Phosphorus (phosphates)
Salinity preferences	Full (30-40 psu), Variable (18-40 psu)
Physiographic preferences	
Biological zone preferences	Infralittoral
Substratum/habitat preferences	Muddy sandy gravel
Tidal strength preferences	Moderately Strong 1 to 3 knots (0.5-1.5 m/sec.), Weak < 1 knot (<0.5 m/sec.)
Wave exposure preferences	Extremely sheltered, Sheltered, Very sheltered
Other preferences	

Additional Information

Species composition

Species found especially in this biotope

- *Venerupis senegalensis*

Rare or scarce species associated with this biotope

-

Additional information

Sensitivity review

Sensitivity characteristics of the habitat and relevant characteristic species

The biotope description and characterizing species are taken from (JNCC, 2015). Sheltered muddy sandy gravel and pebbles in marine inlets, estuaries or embayments with variable salinity or fully marine conditions, support large populations of the pullet carpet shell *Venerupis senegalensis* (accepted name now *Venerupis corrugata*) with the brittlestar *Amphipholis squamata* and the tanaid *Apseudes latreilli*. These species are considered to characterize the biotope and the sensitivity assessments focus on these species. The assessments consider generally the sensitivity of associated polychaetes such as *Mediomastus fragilis*, *Melinna palmata*, *Aphelochaeta marioni*, and tubificid oligochaetes.

Resilience and recovery rates of habitat

The recoverability of the important characterizing species in this biotope, *Venerupis senegalensis*, is the principal factor in assessing the recoverability of the biotope. *Venerupis senegalensis* is a long lived, fast growing species that reaches maturity within one year and spawns several times in one season (Johannessen, 1973b; Perez Camacho, 1980). No information was found concerning number of gametes produced, but the number is likely to be high as with other bivalves exhibiting planktotrophic development (Olafsson *et al.*, 1994). The larvae remain in the plankton for up to 30 days (Fish & Fish, 1996) and hence have a high potential for dispersal. Given these life history features, it is expected that *Venerupis senegalensis* would have strong powers of recoverability. However, recoverability will be influenced by pre and post recruitment processes. The species exhibits pronounced year class variability in abundance (Johannessen, 1973b; Perez Camacho, 1980) which suggests that recruitment is patchy and/or post settlement processes are highly variable. Olafsson *et al.* (1994) reviewed the potential effects of pre and post recruitment processes. Recruitment may be limited by predation of the larval stage or inhibition of settlement due to intraspecific density dependent competition. Post settlement processes affecting survivability include predation by epibenthic consumers, physical disturbance of the substratum and density dependent starvation of recent recruits. Hence, for *Venerupis senegalensis*, an annual predictable population recovery is not certain. However, given the life history characteristics discussed above it is expected that recovery would occur within 5 years and therefore recoverability for *Venerupis senegalensis* is assessed as high.

Species with opportunistic life strategies (small size, rapid maturation and short-lifespan of 1-2 years with production of large numbers of small propagules), include the characterizing polychaetes *Mediomastus fragilis* and *Amphipholis squamata*. Tubificid populations tend to be large and to be constant throughout the year, although some studies have noticed seasonal variations (Giere & Pfannkuche, 1982). Many species, including *Tubificoides benedii* have a two-year reproductive cycle and only part of the population reproduces each season (Giere & Pfannkuche, 1982). Tubificids have a long lifespan (a few years, Giere, 2006), a prolonged reproductive period from reaching maturity to maximum cocoon deposition and internal fertilisation with brooding rather than pelagic dispersal. These factors mean that recolonization is slower than for some opportunistic species which may be present in similar habitats.

Bolam and Whomersley (2003) observed faunal recolonization of fine sediments placed on saltmarsh as a beneficial use and disposal of fine-grained dredged sediments. They found that tubificid oligochaetes began colonising sediments from the first week following a beneficial use scheme involving the placement of fine-grained dredged material on a salt marsh in southeast

England. The abundance of *Tubificoides benedii* recovered slowly in the recharge stations and required 18 months to match reference sites and those in the recharge stations prior to placement of sediments. The results indicate that some post-juvenile immigration is possible and that an in-situ recovery of abundance is likely to require more than 1 year.

Resilience assessment. The majority of species in the biotope are likely to have high recoverability. In light of this, and particularly the recoverability of the important characterizing species, *Venerupis senegalensis*, recoverability of the biotope as a whole is assessed as 'high', to all levels of impact.

NB: The resilience and the ability to recover from human induced pressures is a combination of the environmental conditions of the site, the frequency (repeated disturbances versus a one-off event) and the intensity of the disturbance. Recovery of impacted populations will always be mediated by stochastic events and processes acting over different scales including, but not limited to, local habitat conditions, further impacts and processes such as larval-supply and recruitment between populations. Full recovery is defined as the return to the state of the habitat that existed prior to impact. This does not necessarily mean that every component species has returned to its prior condition, abundance or extent but that the relevant functional components are present and the habitat is structurally and functionally recognisable as the initial habitat of interest. It should be noted that the recovery rates are only indicative of the recovery potential.



Hydrological Pressures

	Resistance	Resilience	Sensitivity
Temperature increase (local)	High Q: High A: Medium C: High	High Q: High A: High C: High	Not sensitive Q: High A: Medium C: High

The geographic range of the key characterizing species *Venerupis corrugata* extends to northern Africa. Therefore, the species must be capable of surviving in higher temperatures than it experiences in Britain and Ireland and thus would be expected to tolerate temperature change over an extended period. A population of *Venerupis corrugata* endured a temperature rise from 13 to 18°C over 5 hours in a rockpool and then a drop to 14°C following inundation by the tide, with no obvious ill effects (Stenton-Dozey & Brown, 1994). Albentosa *et al.* (1994) found that scope for growth of *Venerupis corrugata* increases to an optimum at 20°C and then declines.

Sensitivity assessment. It is expected that *Venerupis corrugata* and other characterizing species would be able to tolerate a long-term, chronic temperature increase and a short-term acute change with no mortality. However, a rapid increase in temperature may result in sub-optimal conditions for growth and reproduction. Resistance of the biotope is assessed as 'High' and resilience as 'High' (by default), so the biotope is considered to be 'Not sensitive' at the pressure benchmark.

	Resistance	Resilience	Sensitivity
Temperature decrease (local)	Low Q: High A: Medium C: NR	High Q: High A: Low C: Medium	Low Q: High A: Low C: Low

The geographic range of *Venerupis corrugata* extends to northern Norway. Therefore, the species must be capable of survival at lower temperatures than it does in Britain and Ireland and would be expected to tolerate a chronic temperature decrease over an extended period. However, in the harsh British winter of 1962-63, when the south coast experienced temperatures 5-6°C below

average for a period of 2 months, *Venerupis corrugata* (studied as *Venerupis pullastra*) suffered 50% mortality around the Isle of Wight and near 100% mortality in Poole Harbour (Waugh, 1964).

Other species within the biotope are likely to be more tolerant. Most oligochaetes, including tubificids and enchytraeids, can survive freezing temperatures and can survive in frozen sediments (Giere & Pfannkuche, 1982). *Tubificoides benedii* (studied as *Pelosclex benedeni*) recovered after being frozen for several tides in a mudflat (Linke, 1939).

Sensitivity assessment. A chronic decrease in temperature at the pressure benchmark is likely to be tolerated. However, an acute decrease in temperature may result in mortalities during the coldest part of the year. Biotope resistance is assessed as 'Low' and resilience as 'High', so that sensitivity is assessed as 'Low'.

Salinity increase (local)

Low

Q: High A: Medium C: NR

High

Q: High A: Low C: Medium

Low

Q: High A: Low C: Low

This biotope is recorded from habitats where salinity is variable (18-35 ppt) or full (30-35 ppt) (JNCC, 2015). Biotopes in variable salinity are likely to be tolerant of an increase in salinity to full as this falls within the natural habitat range. An increase in salinity to hypersaline conditions (>40 ppt) is assessed. No direct evidence was found to assess this pressure for the characterizing species. The ophiuroid *Amphipholis squamata* has been recorded in areas of high salinity (52-55 ppt) in the Arabian Gulf (Price, 1982), indicating local acclimation may be possible. A study from the Canary Islands indicates that exposure to high salinity effluents (47- 50 psu) from desalination plants alter the structure of biological assemblages, reducing species richness and abundance (Riera *et al.*, 2012). Bivalves appear to be less tolerant of increased salinity than polychaetes and were largely absent at the point of discharge.

Sensitivity assessment. High saline effluents alter the structure of biological assemblages. Polychaete species may be more tolerant than bivalves but an increase in salinity is likely to result in declines in species richness and abundance based on Riera *et al.* (2012). Biotope resistance is assessed as 'Low' and resilience as 'High', (following a return to typical conditions). Biotope sensitivity is assessed as 'Low'.

Salinity decrease (local)

Low

Q: High A: Low C: Medium

High

Q: High A: Low C: Medium

Low

Q: High A: Low C: Medium

The biotope occurs in full (30-35 ppt) and variable (18-35 ppt) salinity conditions (JNCC < 2015), biotopes occurring in full salinity are likely to be tolerant of a reduction to variable, as this falls within the natural range. No information was found concerning the effects of decreasing salinity on the species specifically. However, Lange (1972) reported that the muscle volume of *Venerupis rhomboides*, a stenohaline species, increased as salinity decreased, and hence concluded that the species was unable to regulate its muscle volume. *Venerupis japonica* displayed a variety of behavioural reactions in response to reduced salinity in the Sea of Japan (Yaroslavtseva & Fedoseeva, 1978). Salinities typically encountered ranged from 11-30 psu over the course of a day. *Venerupis japonica* was active down to 20 psu, below which it reacted with siphon withdrawal and valve closure. Mortality occurred if salinity remained below 14 psu for an extended period.

Sensitivity assessment. A reduction in salinity may result in changes in biotope composition as some sensitive species are lost and replaced species more tolerant of the changed conditions.

Biotope resistance is therefore assessed as 'Low' and resilience as 'High'. Biotope sensitivity is assessed as 'Medium'.

Water flow (tidal current) changes (local)

High

Q: High A: Medium C: NR

High

Q: High A: High C: High

Not sensitive

Q: High A: Medium C: Low

No direct evidence was found to assess this pressure. This biotope is recorded in areas where tidal flow varies between moderately strong (0.5-1.5 m/s) and weak (>0.5 m/s) (JNCC, 2015).

Sensitivity assessment. A change at the pressure benchmark (increase or decrease) is unlikely to affect biotopes that occur in mid-range flows and biotope resistance is therefore assessed as 'High' and resilience is assessed as 'High', so the biotope is considered to be 'Not sensitive'.

Emergence regime changes

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant to sublittoral biotopes.

Wave exposure changes (local)

High

Q: Low A: NR C: NR

High

Q: High A: High C: High

Not sensitive

Q: Low A: Low C: Low

As this biotope occurs in infralittoral habitats, it is not directly exposed to the action of breaking waves. Associated polychaete and oligochaete species that burrow are protected within the sediment but the characterizing bivalves would be exposed to oscillatory water flows at the seabed. They and other associated species may be indirectly affected by changes in water movement where these impact the supply of food or larvae or other processes. No specific evidence was found to assess this pressure. As the biotope occurs in habitats that are sheltered from wave action (JNCC, 2015), with habitat exposure ranging from sheltered, very sheltered to extremely sheltered (JNCC, 2015), it is considered that a change in wave height at the pressure benchmark would be small and would fall within the natural range.

Sensitivity assessment. The range of wave exposures experienced by the biotope is considered to indicate, by proxy, that the biotope would have 'High' resistance and by default 'High' resilience to a change in significant wave height at the pressure benchmark. The biotope is therefore classed as 'Not sensitive'.

Chemical Pressures

Resistance

Not Assessed (NA)

Q: NR A: NR C: NR

Resilience

Not assessed (NA)

Q: NR A: NR C: NR

Sensitivity

Not assessed (NA)

Q: NR A: NR C: NR

Transition elements & organo-metal contamination

This pressure is **Not assessed** but evidence is presented where available.

The capacity of bivalves to accumulate heavy metals in their tissues, far in excess of environmental levels, is well known. Reactions to sub-lethal levels of heavy metal stressors include siphon

retraction, valve closure, inhibition of byssal thread production, disruption of burrowing behaviour, inhibition of respiration, inhibition of filtration rate, inhibition of protein synthesis and suppressed growth (see review by Aberkali & Trueman, 1985). No evidence was found directly relating to *Fabulina fabula*. However, inferences may be drawn from studies of a closely related species. Stirling (1975) investigated the effect of exposure to copper on *Tellina tenuis*. The 96 hour LC₅₀ for Cu was 1000 µg/l. Exposure to Cu concentrations of 250 µg/l and above inhibited burrowing behaviour and would presumably result in greater vulnerability to predators. Similarly, burial of *Venerupis corrugata*, was inhibited by copper spiked sediments, and at very high concentrations, clams closed up and did not bury at all (Kaschl & Carballeira, 1999). The copper 10 day LC₅₀ for *Venerupis corrugata* (as *Venerupis senegalensis*) was found to be 88 µg/l in sandy sediments (Kaschl & Carballeira, 1999).

Echinoderms are also regarded as being intolerant of heavy metals (e.g. Bryan, 1984; Kinne, 1984) while polychaetes are tolerant (Bryan, 1984).

It should be noted that experimental exposures to heavy metals in the laboratory are likely to be far higher than those encountered in the sea and therefore the real effect *in vivo* may be far less.

Hydrocarbon & PAH contamination

Not Assessed (NA)

Q: NR A: NR C: NR

Not assessed (NA)

Q: NR A: NR C: NR

Not assessed (NA)

Q: NR A: NR C: NR

This pressure is **Not assessed** but evidence is presented where available.

Synthetic compound contamination

Not Assessed (NA)

Q: NR A: NR C: NR

Not assessed (NA)

Q: NR A: NR C: NR

Not assessed (NA)

Q: NR A: NR C: NR

This pressure is **Not assessed** but evidence is presented where available.

Radionuclide contamination

No evidence (NEv)

Q: NR A: NR C: NR

No evidence (NEv)

Q: NR A: NR C: NR

No evidence (NEv)

Q: NR A: NR C: NR

Stamouli & Papadapoulou (1990) investigated bioaccumulation of radioactive trivalent Chromium 51 (⁵¹Cr) in a *Venerupis* species from Greece. ⁵¹Cr is derived from nuclear tests, disposal of radioactive waste and is one of the principal corrosion products of nuclear powered ships. ⁵¹Cr was found to rapidly accumulate in *Venerupis* sp., predominantly in the shell, and reached a stable level in 8 days. No mortality was reported after 20 days. No further information was found concerning the uptake of radionuclides by species in the biotope.

Introduction of other substances

Not Assessed (NA)

Q: NR A: NR C: NR

Not assessed (NA)

Q: NR A: NR C: NR

Not assessed (NA)

Q: NR A: NR C: NR

This pressure is **Not assessed**.

De-oxygenation

Low

Q: High A: Low C: NR

High

Q: High A: Low C: Medium

Low

Q: High A: Low C: Low

Riedel *et al.* (2012) assessed the response of benthic macrofauna to hypoxia advancing to anoxia in

the Mediterranean. The hypoxic and anoxic conditions were created for 3-4 days in a box that enclosed in-situ sediments. In general, molluscs were more resistant than polychaetes, with 90% surviving hypoxia and anoxia, whereas only 10% of polychaetes survived. Epifauna were more sensitive than infauna, mobile species more sensitive than sedentary species and predatory species more sensitive than suspension and deposit feeders. The test conditions did not lead to the production of hydrogen sulphide which may have reduced mortalities compared to some observations.

Tubificoides live relatively deeply buried and can tolerate periods of low oxygen that may occur following the deposition of a fine layer of sediment. In addition, the presence of this species in areas experiencing deposition, such as estuaries, indicate that this species is likely to have a high tolerance to siltation events. *Tubificoides* spp. showed some recovery through vertical migration following the placement of a sediment overburden 6cm thick on top of sediments (Bolan, 2011).

Sensitivity assessment. Riedel *et al.* (2012) provide evidence on general sensitivity trends. The characterizing bivalves are likely to survive hypoxia at the pressure benchmark although the polychaetes present may be less tolerant. Biotope resistance is assessed as 'Low' and resilience as 'High' based on migration, water transport of adults and recolonization by pelagic larvae. Biotope sensitivity is assessed as 'Medium'.

Nutrient enrichment

High

Q: Low A: NR C: NR

High

Q: High A: High C: High

Not sensitive

Q: Low A: Low C: Low

This pressure relates to increased levels of nitrogen, phosphorus and silicon in the marine environment compared to background concentrations. The pressure benchmark is set at compliance with Water Framework Directive (WFD) criteria for good status, based on nitrogen concentration (UKTAG, 2014).

Nutrient enrichment can lead to significant shifts in community composition in sedimentary habitats. Typically the community moves towards one dominated by deposit feeders and detritivores, such as polychaete worms (see review by Pearson & Rosenberg, 1978). The biotope includes species tolerant of nutrient enrichment and typical of enriched habitats (e.g. *Tubificoides benedii*) (Pearson & Rosenberg, 1978). It is likely that such species would increase in abundance following nutrient enrichment, with an associated decline in suspension feeding species such as bivalves.

No information regarding the specific effects of nutrients on *Venerupis corrugata*, the important characterizing species, was found. However, increased nutrients are likely to enhance ephemeral algal and phytoplankton growth, increase organic material deposition and enhance bacterial growth. At low levels, an increase in phytoplankton and benthic diatoms may increase food availability for *Venerupis corrugata*, thus enhancing growth and reproductive potential (e.g. Beiras *et al.*, 1993). However, increased levels of nutrient (beyond the carrying capacity of the environment) may result in eutrophication, algal blooms and reductions in oxygen concentrations (e.g. Rosenberg & Loo, 1988).

Sensitivity assessment. As this biotope is structured by the sediments and water flow rather than nutrient enrichment, the biotope is considered to have 'High' resistance to this pressure and 'High' resilience, (by default) and is assessed as 'Not sensitive'.

Organic enrichment**High**

Q: Low A: NR C: NR

High

Q: High A: High C: High

Not sensitive

Q: Low A: Low C: Low

At the pressure benchmark, organic inputs are likely to represent a food subsidy for the associated deposit feeding species and are unlikely to significantly affect the structure of the biological assemblage or impact the physical habitat. Biotope sensitivity is therefore assessed as 'High' and resilience as 'High' (by default), and the biotope is therefore considered to be 'Not sensitive'.

A Physical Pressures**Resistance****Resilience****Sensitivity****Physical loss (to land or freshwater habitat)****None**

Q: High A: High C: High

Very Low

Q: High A: High C: High

High

Q: High A: High C: High

All marine habitats and benthic species are considered to have a resistance of 'None' to this pressure and to be unable to recover from a permanent loss of habitat (resilience is 'Very Low'). Sensitivity within the direct spatial footprint of this pressure is therefore 'High'. Although no specific evidence is described confidence in this assessment is 'High', due to the incontrovertible nature of this pressure.

Physical change (to another seabed type)**None**

Q: High A: High C: High

Very Low

Q: High A: High C: High

High

Q: High A: High C: High

The biotope is characterized by the sedimentary habitat (JNCC, 2015), a change to an artificial or rock substratum would alter the character of the biotope leading to reclassification and the loss of the sedimentary community including the characterizing bivalve *Venerupis corrugata* and the associated polychaetes that live buried within the sediment.

Sensitivity assessment. Based on the loss of the biotope, resistance is assessed as 'None', recovery is assessed as 'Very low' (as the change at the pressure benchmark is permanent and sensitivity is assessed as 'High'.

Physical change (to another sediment type)**Low**

Q: Low A: NR C: NR

Very Low

Q: High A: High C: High

High

Q: Low A: Low C: Low

The change referred to at the pressure benchmark is a change in sediment classification (based on Long, 2006) rather than a change in the finer-scale original Folk categories (Folk, 1954). For mixed sediments, resistance is assessed based on a change to either coarse sediments or mud and sandy muds.

Sensitivity assessment. Changes in the sediment type may lead to biotope reclassification. Biotope resistance is, therefore, assessed as 'Low' (as some species may remain), as resilience is Very low (the pressure is a permanent change), sensitivity is, therefore, High.

Habitat structure changes - removal of substratum (extraction)**None**

Q: High A: High C: High

Medium

Q: Low A: NR C: NR

Medium

Q: Low A: Low C: Low

Sedimentary communities are likely to be highly intolerant of substratum removal, which will lead to partial or complete defaunation, exposing underlying sediment which may be anoxic and/or of a different character or bedrock and lead to changes in the topography of the area (Dernie *et al.*, 2003). Any remaining species, given their new position at the sediment/water interface, may be exposed to conditions to which they are not suited. Removal of 30 cm of surface sediment will remove the polychaete and oligochaete community and other species present in the biotope. Recovery of the biological assemblage may take place before the original topography is restored, if the exposed, underlying sediments are similar to those that were removed. Hydrodynamics and sedimentology (mobility and supply) influence the recovery of soft-sediment habitats (Van Hoey *et al.*, 2008).

Sensitivity assessment. Extraction of 30 cm of sediment will remove the characterizing biological component of the biotope. Resistance is assessed as 'None' and biotope resilience is assessed as 'Medium'. Biotope sensitivity is therefore 'Medium'.

Abrasion/disturbance of the surface of the substratum or seabed

Medium

Q: Low A: NR C: NR

High

Q: High A: Low C: Medium

Low

Q: Low A: Low C: Low

Abrasion may damage or kill a proportion of the population of the characterizing species. Biotope resistance is assessed as 'Medium' and resilience as 'High', so sensitivity is assessed as 'Low'.

Penetration or disturbance of the substratum subsurface

Medium

Q: High A: Low C: NR

High

Q: High A: Low C: Medium

Low

Q: High A: Low C: Low

Gilkinson *et al.* (1998) simulated the physical interaction of otter trawl doors with the seabed in a laboratory test tank using a full-scale otter trawl door model. Between 58% and 70% of the bivalves in the scour path that were originally buried were completely or partially exposed at the test bed surface. However, only two out of a total of 42 specimens showed major damage. The pressure wave associated with the otter door pushes small bivalves out of the way without damaging them. Where species can rapidly burrow and reposition (typically within species occurring in unstable habitats) before predation mortality rates will be relatively low. These experimental observations are supported by diver observations of fauna dislodged by a hydraulic dredge used to catch *Ensis* spp. Small bivalves were found in the trawl tracks that had been dislodged from the sediments, including the venerid bivalves *Dosinia exoleta*, *Chamelea striatula* and the hatchet shell *Lucinoma borealis*. These were usually intact (Hauton *et al.*, 2003a) and could potentially reburrow.

Sensitivity assessment. Biotope resistance is assessed as 'Medium' as some species will be displaced and may be predated or injured and killed. Biotope resilience is assessed as 'High' as most species will recover rapidly and the biotope is likely to still be classified as SS.SMx.IMx.VsenAsquAps following disturbance. Biotope sensitivity is therefore assessed as 'Low'.

Changes in suspended solids (water clarity)

Medium

Q: Low A: NR C: NR

High

Q: High A: Low C: Medium

Low

Q: Low A: Low C: Low

A change in turbidity at the pressure benchmark is assessed as an increase from intermediate 10-100 mg/l to medium (100-300 mg/l) and a change to clear (<10 mg/l). An increase or decrease in turbidity may affect primary production in the water column and indirectly alter the availability of phytoplankton food available to species in filter-feeding mode. However, phytoplankton will also be transported from distant areas and so the effect of increased turbidity may be mitigated to some extent. According to Widdows *et al.* (1979), growth of filter-feeding bivalves may be impaired at suspended particulate matter (SPM) concentrations >250 mg/l.

Venerupis corrugata is an active suspension feeder, trapping food particles on the gill filaments (ctenidia). An increase in suspended sediment is, therefore, likely to affect both feeding and respiration by potentially clogging the ctenidia. In *Venerupis corrugata*, increased particle concentrations between low and high tide resulted in increased clearance rates and pseudofaeces production with no significant increase in respiration rate (Stenton-Dozey & Brown, 1994).

Changes in turbidity and seston are not predicted to directly affect deposit feeding polychaetes and oligochaetes which live within sediments. The majority of species in the biotope are either suspension feeders or deposit feeders and therefore rely on a supply of nutrients in the water column and at the sediment surface. A decrease in suspended organic material would result in decreased food availability for suspension feeders. It would also result in a decreased rate of deposition on the substratum surface and therefore a reduction in food availability for deposit feeders. This would be likely to impair growth and reproduction.

Sensitivity assessment. No direct evidence was found to assess impacts on the characterizing and associated species. The characterizing, suspension feeding bivalves are not predicted to be sensitive to decreases in turbidity and may be exposed to, and tolerant of, short-term increases in turbidity following sediment mobilization by storms and other events. An increase in suspended solids, at the pressure benchmark may have negative impacts on growth and fecundity by reducing filter feeding efficiency and imposing costs on clearing. Biotope resistance is assessed as 'Medium' as there may be some shift in the structure of the biological assemblage although the biotope is likely to still be characterized as SS.SMx.IMx.VsenAsquAps. Biotope resilience is assessed as 'High' (following restoration of typical conditions) and sensitivity is assessed as 'Low'.

Smothering and siltation rate changes (light)

Low

Q: High A: Low C: NR

High

Q: High A: Low C: Medium

Low

Q: High A: Low C: Low

The addition of fine material will alter the character of this habitat by covering it with a layer of dissimilar sediment and will reduce suitability for the species associated with this feature. Recovery will depend on the rate of sediment mixing or removal of the overburden, either naturally or through human activities. Recovery to a recognisable form of the original biotope will not take place until this has happened. In areas where the local hydrodynamic conditions are unaffected, fine particles will be removed by wave action moderating the impact of this pressure. The rate of habitat restoration would be site-specific and would be influenced by the type of siltation and rate. Long-term or permanent addition of fine particles would lead to re-classification of this biotope type (see physical change pressures).

Suspension feeding bivalves may be sensitive to deposition. The additions of silts to a *Spisula solida* bed in Waterford Harbour (Republic of Ireland) from earthworks further upstream, for example, reduced the extent of the bed (Fahy *et al.*, 2003). No information was provided on the depth of any deposits.

Venerupis corrugata typically burrows to a depth of 3-5 cm and is often attached to small stones or shell fragments by byssal threads. It is an active suspension feeder and therefore requires its siphons to be above the sediment surface in order to maintain a feeding and respiration current. Kranz (1972, cited in Maurer *et al.*, 1986) reported that shallow burying siphonate suspension feeders are typically able to escape smothering with 10-50 cm of their native sediment and relocate to their preferred depth by burrowing. This is likely to apply to the proportion of the *Venerupis corrugata* population which is not firmly attached by byssal threads. However, those individuals which are attached may be inhibited from relocating rapidly following smothering with 5 cm of sediment and some mortality is expected to occur.

Sensitivity assessment. This biotope is exposed to tidal streams which may remove some sediments and the bivalves and polychaetes are likely to be able to survive short periods under sediments and to reposition. Based on *Venerupis corrugata*, biotope resistance is assessed as 'Low' and resilience as 'High'. So that biotope sensitivity is assessed as 'Low'.

Smothering and siltation rate changes (heavy)

Low

Q: High A: Low C: NR

High

Q: High A: Low C: Medium

Low

Q: High A: Low C: Low

No direct evidence was found to assess this pressure for *Venerupis senegalensis* and other characterizing species. Powilleit *et al.* (2009) studied responses to smothering for three bivalves; *Arctica islandica*, *Limecola balthica* and *Mya arenaria*. These successfully burrowed to the surface of a 32–41cm deposited sediment layer of till or sand/till mixture and restored contact with the overlying water. These high escape potentials could partly be explained by the heterogeneous texture of the till and sand/till mixture with 'voids'. In comparison to a thick coverage, thin covering layers (i.e. 15–16 cm and 20 cm) increased the chance of the organisms to reach the sediment surface after burial. While crawling upward to the new sediment surfaces burrowing velocities of up to 8 cm/day were observed for the bivalves.

Sensitivity assessment. The pressure benchmark (30 cm deposit) represents a significant burial event and the deposit may remain for some time in wave sheltered areas. Some impacts on characterizing are likely to occur as it is considered unlikely that significant numbers of the population could reposition. Placement of the deposit will, therefore, result in a defaunated habitat until the deposit is recolonized. Biotope resistance is assessed as 'Low' as some removal of deposit and vertical migration through the deposit may occur. Resilience is assessed as 'High' as migration and recolonization of characterizing species is likely to occur within two years, biotope sensitivity is therefore assessed as 'Low'.

Litter

Not Assessed (NA)

Q: NR A: NR C: NR

Not assessed (NA)

Q: NR A: NR C: NR

Not assessed (NA)

Q: NR A: NR C: NR

Not assessed.

Electromagnetic changes

No evidence (NEv)

Q: NR A: NR C: NR

No evidence (NEv)

Q: NR A: NR C: NR

No evidence (NEv)

Q: NR A: NR C: NR

No evidence.

Underwater noise changes

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant.

Introduction of light or shading

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

All characterizing species live in the sediment and do not rely on light levels directly to feed so limited direct impact is expected. As this biotope is not characterized by the presence of primary producers it is not considered that shading would alter the character of the habitat directly.

Barrier to species movement

High

Q: Low A: NR C: NR

High

Q: High A: High C: High

Not sensitive

Q: Low A: Low C: Low

The key characterizing bivalve species produce pelagic larvae as do many of the polychaete species. Barriers that reduce the degree of tidal excursion may alter larval supply to suitable habitats from source populations. Conversely, the presence of barriers may enhance local population supply by preventing the loss of larvae from enclosed habitats. As the bivalve species characterizing the biotope are widely distributed and produce large numbers of larvae capable of long distance transport and survival, resistance to this pressure is assessed as 'High' and resilience as 'High' by default. This biotope is therefore considered to be 'Not sensitive'. Some species such as the oligochaetes that occur within the biotope have benthic dispersal strategies (via egg masses laid on the surface) and water transport is not a key method of dispersal over wide distances

Death or injury by collision

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant' to seabed habitats. NB. Collision by grounding vessels is addressed under 'surface abrasion.

Visual disturbance

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

The majority of the species in the biotope, including *Venerupis senegalensis*, have very little or no visual acuity, and are therefore unlikely to be intolerant of visual disturbance. Some species, however, respond to visual disturbance by withdrawal of feeding structures and are therefore likely to experience some energetic cost through loss of feeding opportunities. *Aphelocheata marioni*, for example, feeds only at night, and responds to sudden light pollution by the retraction of palps and cirri and cessation of all activity for some minutes (Farke, 1979). This pressure is therefore considered 'Not relevant'.

**Biological Pressures**

Resistance

Resilience

Sensitivity

Genetic modification & translocation of indigenous species

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

Not relevant (NR)

Q: NR A: NR C: NR

Key characterizing species are not translocated or cultivated and this pressure is considered to be 'Not relevant'. In Europe, *Venerupis corrugata* is reared in hatcheries with subsequent relocation to natural habitats to grow, this assessment will require updating if such practices became established in the UK.

Introduction or spread of invasive non-indigenous species

None

Q: Low A: NR C: NR

Very Low

Q: Low A: NR C: NR

High

Q: Low A: Low C: Low

The slipper limpet *Crepidula fornicata* may settle on stones in substrates and hard surfaces such as bivalve shells and can sometimes form dense carpets which can smother bivalves and alter the seabed, making the habitat unsuitable for larval settlement. Dense aggregations trap suspended silt, faeces and pseudofaeces altering the benthic habitat. Where slipper limpet stacks are abundant, few other bivalves can live amongst them (Fretter & Graham, 1981; Blanchard, 1997). Muddy and mixed sediments in wave sheltered areas are probably optimal, but *Crepidula fornicata* has been recorded from a wide variety of habitats including clean sands and areas subject to moderately strong tidal streams (Blanchard, 1997; De Montaudouin & Sauriau, 1999). Bohn *et al.* (2015) report that in the Milford Haven Waterway (MHW) in south west Wales, UK, subtidally, highest densities were found in areas of high gravel content (grain sizes 16-256 mm), suggesting that the availability of this substrata type is beneficial for its establishment.

Although not currently established in UK waters, the whelk *Rapana venosa* may spread to UK habitats from Europe. Both *Rapana venosa* and the introduced oyster drill *Urosalpinx cinerea* predate on bivalves and could therefore negatively affect bivalve species.

Sensitivity assessment. The sediments characterizing this biotope are likely to be too mobile or otherwise unsuitable for most of the recorded invasive non-indigenous species currently recorded in the UK. The slipper limpet may colonize this habitat resulting in habitat change and potentially classification to the biotope which is found in similar habitats SS.SMx.IMx.CreAsAn. *Didemnum* sp. and non-native predatory gastropods may also emerge as a threat to this biotope, although more mobile sands may exclude *Didemnum*. Based on *Crepidula fornicata*, biotope resistance is assessed as 'None' and resilience as 'Very Low' (as removal of established non-native is unlikely), so biotope sensitivity is assessed as 'High'

Introduction of microbial pathogens

Medium

Q: High A: High C: High

High

Q: High A: Low C: Medium

Low

Q: High A: Low C: Medium

Bacterial diseases are frequently found in molluscs during their larval stages, but seem to be relatively insignificant in populations of adult animals (López *et al.*, 2004). This may be due to the primary defence mechanisms of molluscs, phagocytosis and encapsulation, which fight against small-sized pathogens, and whose resistance may be age related (Sindermann, 1990, from López-Flores *et al.*, 2004). Pathogens that have been recorded to affect *Venerupis* spp. include 'Hinge ligament disease', caused by a *Cytophaga*-like bacteria, was detected in *Venerupis philippinarum* (*Ruditapes philippinarum*) in the US. The disease has little or no effect on healthy growing juveniles (Bower *et al.*, 1994a). Virus-like particles similar to picornaviruses and

parvoviruses have been associated with brown muscle disease in *Venerupis philippinarum* (*Ruditapes philippinarum*) populations with mortalities, in France (Dang & De Montaudouin, 2009). *Perkinsus* spp. have been associated with mass mortalities of *Venerupis decussata* from the south coast of Portugal, and with epizootic mortalities of *Venerupis philippinarum* in Korea, China and Japan (Villalba *et al.*, 2004; Choi & Park, 2005). Navas *et al.* (1992) investigated the parasites of *Venerupis senegalensis* (studied as *Venerupis pullastra*), from a population in south west Spain. The following were recorded:

- 36.6% prevalence of *Perkinsus atlanticus*; trophozoites found in the connective tissue of different organs with a very intensive hemocytic response, encysting the parasite and destroying tissue structure.
- 96.6% prevalence of ciliates in gills, including *Trichodina* sp.
- 11.8% prevalence of turbellarians.
- 11.1% prevalence of trematodes.

Perkinsus atlanticus was also recorded as causing mortality in *Venerupis decussata* and *Venerupis aureus*. Freire-Santos *et al.* (2000) recorded the presence of oocysts of *Cryptosporidium* sp. in *Venerupis corrugata* (studied as *Venerupis pullastra*) collected from north west Spain and destined for human consumption.

Little information on pathogens is available for other species that characterize this biotope, although Gibbs (1971) recorded that nearly all of the population of *Aphelocheata marioni* in Stonehouse Pool, Plymouth Sound, was infected with a sporozoan parasite belonging to the acephaline gregarine genus *Gonospora*, which inhabits the coelom of the host. No evidence was found to suggest that gametogenesis was affected by *Gonospora* infection and there was no apparent reduction in fecundity.

Sensitivity assessment. The parasite loads of the bivalves discussed above have been proven to cause mortality and therefore biotope resistance is assessed as 'Medium' as there may be a minor decline in species richness in the biotope and a reduction in abundance of the key characterizing species *Venerupis corrugata*. Resilience is assessed as 'High' and biotope sensitivity is assessed as 'Low'.

Removal of target species

Low

Q: Low A: NR C: NR

High

Q: High A: Low C: Medium

Low

Q: Low A: Low C: Low

Venerupis corrugata is a very important commercial shellfish in Spain. It is harvested from the wild and raised in aquaculture (Jara-Jara *et al.*, 2000).

Sensitivity assessment. Biotope resistance to targeted removal is assessed as 'Low' and resilience as 'High', as the habitat is likely to be directly affected by removal but the targeted species are likely to recolonize rapidly. Some variability in species recruitment, abundance and composition is natural and therefore a return to a recognizable biotope should occur within 2 years. Repeated chronic removal would, however, impact recovery.

Removal of non-target species

Low

Q: Low A: NR C: NR

High

Q: High A: Low C: Medium

Low

Q: Low A: Low C: Low

Species within the biotope are not functionally dependent on each other, although biological

interactions will play a role in structuring the biological assemblage through predation and competition. Removal of adults may support recruitment of juvenile bivalves by reducing competition for space and consumption of larvae.

Removal of species would also reduce the ecological services provided by these species such as secondary production and nutrient cycling.

Sensitivity assessment. Species within the biotope are relatively sedentary or slow moving, although the infaunal position may protect some burrowing species from removal. Biotope resistance is therefore assessed as 'Low' and resilience as 'High', as the habitat is likely to be directly affected by removal but some species will recolonize rapidly. Biotope sensitivity is assessed as 'Low'.

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